

## PROSPERING IN A GLOBAL ECONOMY

(KEYNOTE)

That was a mighty generous introduction. It reminds me of my first day serving on the faculty at Princeton. After having spent my entire career until that time in either industry or government, I had been invited to deliver the welcoming lecture to the incoming freshman engineering students. As the dean was making his introductory remarks I was busily flipping through my lecture notes, not paying much attention to what he was saying—until suddenly I heard him pronounce, “And now, we will hear from *Professor* Augustine.” For just an instant—and this is true—the thought went through my mind, “Gee, what a coincidence. They have some guy here with the same name as me!”

On the other hand, when I was granted an honorary degree by my alma mater—and needless to say I was very proud—*The New York Times* story carried the following headline: “Mohammed Ali and Three Others Receive Princeton Degrees!” I think I was the first of “the others.”

Whatever the case, I am extremely honored to be a part of this extraordinary gathering. As you may know, I care deeply about the subject of education. As we say in the aerospace business, one can never be certain how much runway one has left in life, but I plan to continue devoting a major portion of mine to promoting education and basic research.

The overarching reason for my commitment is that I have studied the evidence of the impact education has on a nation’s prosperity. Further, I have witnessed first-hand the impact an education can have on an individual life. I was the first person in my family to have the opportunity to attend college; the second to attend high school. Make no mistake, my parents knew the value of an education—and the opportunity I was given has made all the difference in my life.

I, of course, am not an educator. But my message can be summarized in the following quotation: “A college diploma is one of the keys to the good-paying jobs of the 21<sup>st</sup> century, and businesses seek to operate where there are well-educated workers with the skills necessary to make their

enterprises successful.” Those are, of course, the words of Governor McDonnell. And I would add the obvious: in order to qualify to pursue one of those diplomas requires a solid pre-K-12 education as well.

Today our educational system provides the two most important ingredients of a nation’s or a state’s standard of living: knowledge... and capable people.

But I am getting ahead of my story. Let me turn the clock back a little bit in time...say, about 200 million years! *Geologists* tell us that something over 200 million years ago many of what today are the earth’s major continents were joined together in a single “supercontinent” now known as Gondwanaland. It included, in part, what today is South America, Africa, Australia, Antarctica, Arabia and the Indian Peninsula. Over time, these land masses slowly drifted apart...and their influence on each other diminished correspondingly.

Then, according to the *economists*, in just the last few decades all these continents suddenly came crashing back together. As Tom Friedman put it in his book, *The World is Flat*, “Globalization has accidentally made Beijing, Bangalore and Bethesda next door neighbors.” Now this is a truly remarkable happenstance...over 200 million years of drifting apart effectively reversed in just a few decades.

Much of this change is attributable to developments in science and engineering, two of which I believe underlie what we call globalization. I refer to jet aircraft that make it possible to move “things,” including people, around the planet at nearly the speed of sound; and to information networks that now move ideas and information around the world literally at the speed of light...and virtually at no cost. The result, in the words of Frances Cairncross writing in *The Economist*, is that “*Distance is Dead*.”

Yes, distance *is* dead. In fact, Nobel Laureate Arthur Compton wrote in 1927 that, “Communication by printed and spoken word and television [will be] much more common ... so that the whole earth will be one great neighborhood.”

Consider the example of one not particularly complex product: a toothbrush. The CEO of Bausch and Lomb has pointed out that the toothbrush his company sells had its electromechanical design performed in Germany and Japan, its motors are from China, the brush head is from Ohio, the batteries from Japan, the molded plastics from Georgia, the charging base from Hong Kong and the final assembly is performed in Mexico. Customers are all around the world.

One of the more profound consequences of globalization is that Americans no longer compete for jobs simply with their neighbors down the street or the graduates of a nearby high school or university...rather, they must now also compete with their new neighbors in Taiwan, Toulouse and Timbuktu.

There are numerous real-world examples of the Death of Distance already to be found in our daily lives. For example:

- Many students are now being taught by renowned professors located thousands of miles away, rather than by local graduate students. Further, the campus library is no longer in a building but is somewhere in cyberspace, and is accessible from a device the students can carry in their pocket.
- In India, to better prepare students for jobs in call centers, courses are offered on how to speak with a mid-western accent. The workers in some centers are encouraged to adopt a pseudonym that will make American callers more comfortable. My neighbor talked to a fellow in India who insisted his name was “Abraham Lincoln.” Really!
- Visitors to one firm’s offices located not far from the White House are greeted by a woman whose image appears on a flat-screen display in the lobby. But she is not in Washington, D.C. — she lives in Pakistan.
- The CAT scans of patients in a number of U.S. hospitals are now read by radiologists in Australia or India.

- “Pilots” at consoles in Nevada fly unmanned aerial vehicles attacking targets in Afghanistan, then drive home in time for dinner.
- And a patient in Strasbourg, France, had his gallbladder removed by a surgeon in New York using a remotely controlled robot. As an engineer, I hope they had a back-up surgeon somewhere around!

Ironically, in this new world it will be the “established” nations that are most challenged. Why? Well, for starters, nine factory workers can be hired in Mexico for the cost of one in the U.S. I visited a plant in Vietnam where twenty assembly workers could be hired for the cost of one in the U.S. Five chemists can be employed in China for the cost of one in the U.S. and eight engineers can be hired in India for the cost of one in the U.S.

According to the Hamilton Institute the median income of men in the U.S. between 25 and 64 years old *fell* 28 percent over the forty-year period ending in 2009. In the case of high school graduates who did not attend college, the drop in income was 47 percent.

Meanwhile, a survey of U.S. adults who were asked whether a college education was a good financial investment inexplicably saw the fraction who said “yes,” drop from 81 percent in 2008 to 57 percent four years later.

So what are we doing to assure that Americans can in the future enjoy a standard of living approximating the best available...which is in large part simply another way of saying, “to have a good job”?

That was the question a bipartisan group from the House and the Senate asked the National Academies of Science, Engineering and Medicine several years ago. In search of an answer, the Academies formed a 20-member committee, which I was privileged to chair, composed of individuals with highly diverse professional backgrounds that included public and private university presidents, Nobel Laureates, CEO’s, former presidential appointees, and the head of a

state public school system. Two of our members subsequently took positions in President Obama's cabinet, one as Secretary of Energy and the other as Secretary of Defense.

The committee produced a document that has become known as the "Gathering Storm" report, after the first line in its title. The top two items on the prioritized list of recommendations in the report were to fix the nation's K-12 public education system and to significantly increase our nation's investment in basic research.

In still another effort in which I participated, the bipartisan Hart-Rudman Commission, whose task was to propose national security initiatives, stated, "...second only to a weapon of mass destruction detonating on an American city, we can think of nothing more dangerous than a failure to manage properly science, technology and education for the common good."

The Gathering Storm committee concluded that the only reasonable answer to the global competitiveness challenge facing America is through leadership in *innovation*; in most cases that requires creating new knowledge through leading-edge research; applying that knowledge through world-class engineering; and being *first* to market with the resulting new products and services through extraordinary entrepreneurship.

The Academies' conclusion was strongly influenced by the substantial number of studies that have demonstrated that over the past half-century 50 to 85 percent of the increase in the nation's GDP is attributable to advancements in science and engineering, as is two-thirds of the nation's increase in productivity—strong indicators of the creation of jobs and improvement in the standard of living, respectively.

While the Gathering Storm report did emphasize the importance of science and engineering, it did not focus, *per se*, on jobs *for* scientists, engineers or other STEM workers. Scientists and engineers comprise only four percent of the nation's workforce, a number that if increased by 100 percent would by itself not prove extremely consequential to the nation's overall unemployment dilemma. Rather, the point was made that the work performed by that four percent of the workforce disproportionately creates jobs for the other 96 percent.

For example, the invention of the iPad, the Blackberry and the iPhone, all rooted in the much earlier work performed in solid state physics, created jobs not only for scientists and engineers but also for factory workers, salespersons, advertisers and even musicians. A recent study reported in the Journal of International Commerce and Economics pointed out that in 2006, the 700 engineers working on Apple's iPod were accompanied by 14,000 other workers in the U.S. and nearly 25,000 abroad. Floyd Kvamme, a highly successful entrepreneur, has said that, "Venture capital is the search for good engineers." Steve Jobs told the president of the United States that the reason Apple employs 700,000 workers abroad is because it can't find 30,000 engineers in the U.S.

Yet, a recent NSF study of the fraction of first-degrees going to engineers in 93 nations placed the U.S. in 79<sup>th</sup> place. The country most closely matching the U.S. in participation in science and engineering was Mozambique. The only countries falling below the U.S. were Bangladesh, Brunei, Burundi, Cambodia, Cameroon, Cuba, Zambia, Guyana, Lesotho, Luxembourg, Madagascar, Namibia, Saudi Arabia and Swaziland.

I should note at this point that I have emphasized the importance of STEM education because of the impact it has on creating jobs and, no doubt, because I am an engineer. But I would hasten to add that the greatest failing of the engineers I have known—and at one point I had 82,000 of them working for me—is a chronic inability to express themselves in writing. Further, anyone, STEM-trained or otherwise, who is to be trusted as a leader in our society should have been exposed to such subjects as history, economics and ethics.

America is blessed with unarguably the finest universities in the world. These represent one of the nation's greatest comparative advantages. According to *The Times of London*, the top five universities in the entire world, and 18 of the top 25, are located in the United States. Suddenly, however, as state and local tax revenues recently declined precipitously due to the economic downturn, U.S. public institutions have found themselves facing severe unanticipated budget shortfalls—some requiring Draconian corrective measures...such as the 65 percent tuition

increase imposed by the State of California on its universities over a three-year period. State funding for U.S. colleges and universities per student is now at a 25-year low.

The steps being taken by U.S. academic institutions to offset the budget shortfalls confronting them have not gone unnoticed elsewhere in the world. Lists are being made of outstanding research-faculty members who might be attracted to leave the United States. This threat is exacerbated in our engineering schools by the fact that over 40 percent of faculty came from abroad in the first place. One foreign university that I recently visited had hired 13 senior faculty members in the past few years—twelve of them from U.S. universities.

And that brings us to the presumptive source of much of America's future science and engineering talent: our own pre-K-12 system...or, more accurately, system of systems, with its 14,000 independent school districts.

In international tests, U.S. K-12 students are firmly ensconced near the bottom of the global class. In the most recent assessments—the (2009) so-called PISA test—involving 15-year-olds from 33 OECD countries, U.S. students ranked 14<sup>th</sup> in reading, 17<sup>th</sup> in science and 25<sup>th</sup> in mathematics. That same year the writing scores were the lowest ever recorded by the U.S., and a report by the Hartland Program on Education Policy and Governance ranked the U.S. high school class of 2011 32<sup>nd</sup> in overall performance among the 33 OECD nations participating in the PISA tests.

McKinsey & Co., the management consultant, sought to link GDP...a not unreasonable surrogate for the standard of living in a country with a relatively stable population...with K-12 educational achievement. It concluded that if U.S. youth could match the academic performance of students in Finland, our economy would be between 9 and 16 percent larger. That is, about two *trillion* dollars a year greater.

Make no mistake, America's K-12 grades are blessed with a number of outstanding students and many exceptional teachers and many capable administrators...but on average—by world standards—we are failing. Some states are of course doing better than others. Virginia is among

the better, but certainly not the best. Among its universities, Virginia is among the best. But the problem is that how Virginia compares with Massachusetts or Maryland really doesn't matter all that much anymore. What counts is how Virginia compares with Mumbai and Macao.

You may recall how strongly Americans reacted when we discovered a few years ago that our Olympic basketball team was no longer ranked first in the world, yet we seem remarkably indifferent that we are now ranked by respected institutions as:

6<sup>th</sup> in innovation-based competitiveness

10<sup>th</sup> in percent of adults with college degrees

16<sup>th</sup> in college completion rate

20<sup>th</sup> in high school completion rate

40<sup>th</sup> in improvement of innovation-based competitiveness in the past decade

48<sup>th</sup> in the quality of overall K-12 math and science education

The most important single action we could take would be to assure that every classroom has a teacher with a degree in the core subject they teach. The fact that we do not do this tells us a great deal about our nation's priorities. *US News and World Report* observes that a high school teacher in the United States must work 43 hours to make \$1,000. But a corporate CEO can, on average, do so in two hours and 55 minutes. Kobe Bryant takes five minutes and 30 seconds, and Howard Stern needs labor only 24 seconds in *his* chosen profession. If we are willing to pay more to assure that our city's football team has a good quarterback than to assure that our children have good teachers, then we shouldn't be surprised that forty-six percent of the nation's teachers abandon the classroom within five years in order to pursue other careers. Teaching our nation's youth should be the most respected profession in America.

Further complicating the issue is that the *requirement* for higher education in the workforce is gaining strength. A Georgetown University Workforce report states that, "Jobs for workers with a high school diploma or less still exist but are quickly declining. Only thirty-seven percent of all jobs in 2018 will be for workers who have either a high school diploma or incomplete high



school education with some on-the-job training. That number is down from 72 percent in 1973, 44 percent in 1992, and 41 percent in 2007.”

Nonetheless, it would seem that, for example, our community colleges could help a great deal by expanding their offerings that lead to certification in a trade. This emphasis has often been cited as one of the reasons for the current strength of Germany’s economy.

It should also not go unnoted that education—which for several hundred years has consisted of a teacher, a book, a blackboard and a piece of chalk, is about to go through a technological revolution of its own. One of the most important consequences of this is that lifelong learning will be greatly facilitated. The pace of change of knowledge is indicated in the remarks of Craig Barrett, former CEO of Intel, who points out that 90 percent of Intel’s revenues on the last day of a year come from products that didn’t exist on the first day of that year. A scientist or engineer who is not committed to life-long learning faces the same fate as an athlete being professionally middle-aged by the time they are thirty.

Turning to the subject of university research, the source of a large share of new knowledge, the total federal annual *investment* in research in mathematics, engineering and the physical sciences is about equal to the amount by which U.S. healthcare costs *increase* every ten weeks. It is therefore perhaps not surprising that the UK’s Royal Society projected that China will overtake the U.S. in scientific output by 2013, as measured by the number of articles and citations in recognized journals. In the case of granting *U.S.* patents, the number of domestic grantees has already been surpassed by foreign grantees – that occurred in 2008.

Our nation’s future resides to an ever increasing extent upon our federal government providing the funds needed to support research that will largely be conducted in the nation’s universities. So, too, does it depend upon strengthening the ties between our corporations and our research universities. Sadly, the great industrial research institutions such as Bell Labs have seen their best days due to market pressures for short-term results.

Margaret Thatcher perhaps best summarized the significance, as well as complexities, of basic research in the following terms:

“...although basic science can have colossal economic rewards, they are totally unpredictable...the value of Faraday’s work today must be higher than the capitalization of all shares on the stock exchange ... The greatest economic benefits of scientific research have always resulted from advances in fundamental knowledge rather than the search for specific applications ... transistors were not discovered by the entertainment industry ... but by people working on wave mechanics and solid state physics. [Nuclear energy] was not discovered by oil companies with large budgets seeking alternative forms of energy, but by scientists like Einstein and Rutherford ...”

It is tempting, especially to people who are disciples of Adam Smith, to say “Let market forces solve the competitiveness and standard of living problems.” But that, from a U.S. perspective, *is* the problem. Market forces *are* solving the competitiveness problem. Companies are doing so by creating jobs *outside* the United States. In fact, U.S. multi-nationals actually created 2.9 million offshore jobs during the tenuous economy of the first decade of this century. The problem is that the number of workers they employed in the U.S. was concurrently *reduced* by 2.4 million. The largest 35 firms in the U.S. are now creating three times more jobs abroad than in the U.S.

Intel’s Howard High’s comments are fairly representative: “We go where the smart people are. Now our business operations are two-thirds in the U.S. and one-third overseas. But that ratio will flip over in the next ten years.” Or, in the words of DuPont’s then-CEO, Chad Holliday, “If the U.S. doesn’t get its act together, DuPont is going to go to the countries that do.” Bill Gates says, “We are all going where the high I.Q.’s are.” Dell announced that it will close its last large manufacturing facility in the U.S. and invest over \$100B in China.

Several years ago in testimony before a committee of the Congress I was seeking increased investment in education and research. One member, obviously frustrated, asked, “Mr.

Augustine, do you not understand that we have a budget crisis in this country?" I responded by saying that I am an aeronautical engineer and during my career I have worked on a number of airplanes that during their development programs were too heavy to fly. Never once did we solve the problem by removing an engine. Education and the creation of knowledge are the engines that drive our economy, jobs and standard of living. Only by working together can government, industry and academia meet the great challenge we confront.

Winston Churchill said that you can always count on the Americans to do the right thing...after they have tried everything else. In this case, we need to get it right *this* time.

Thank you.